Diode-Laser Holographic Imaging System Applied to the Study of Fluids in Microgravity

William K. Witherow/ES76
205–544–7811
E-mail: bill.witherow@msfc.nasa.gov

The objective of the proposed study is to create a compact holographic system that will fit inside a Shuttle locker. Holography is an important research method because it records an image of the entire volume of a test cell at a given instant in time. When a hologram is constructed, it records the wave front coming from the test cell. Then when the hologram is reconstructed the same wave front is reproduced. The reconstructed wave front can be analyzed by the same optical techniques that could have been used on the original test cell.

This capability is important in many areas of research, such as solution crystal growth, fluid physics, and particle phenomena. For example, quantitative studies of the growth of transparent dispersions require diameter measurements from numerous microscopic droplets at a given instant of time in order to produce statistically significant results. Typically the droplets will be undergoing changes in position or size as the experiment progresses. Accurate measurement of the entire population of droplets is impossible by normal techniques. However, by recording a hologram of the experiment the entire test cell volume is stored. The entire test cell from the reconstructed hologram can be investigated by microscopy to measure all of the droplets.

The primary objective of the proposed research is the development of a compact, state-of-the-art, modular holographic imaging system, based on laser-diode technology which will incorporate micro-optics in order to record full three-dimensional images of the test cell. The apparatus is designed to be compatible with a variety of test cell modules. The device could find applications in ground-based laboratories, as well as reduced gravity environments, such as the Space Shuttle, the KC–135 aircraft and sounding rockets. The goal of the design effort is to develop and test a compact, state-of-the-art, modular holographic imaging system. No such integrated apparatus is presently available.

A second objective of the research described in this proposal is to develop a compact apparatus designed for such low-gravity fluid physics studies. This fluids module will be designed to plug in to the imaging system, and will be used in order to verify the functionality of the imaging system. The module will be designed to have several fluid handling functions: producing well-defined dispersions having user-specified characteristics, deploying numerous small droplets of selected volumes, and delivering selected volumes of fluid.

An initial breadboard system has been constructed to test the capabilities of the diode laser to construct holograms. In-line holograms of static 200-µm-diameter glass beads suspended in water and of calibration test patterns have been made. Side-band holograms of melting ice in water (fig. 136) have also been made. The capabilities of the initial system are being evaluated. The holographic system was flown on the KC–135 flight in May 1995 has been established. A fluids processing module was developed for the KC–135 flight with heating and mixing capabilities.

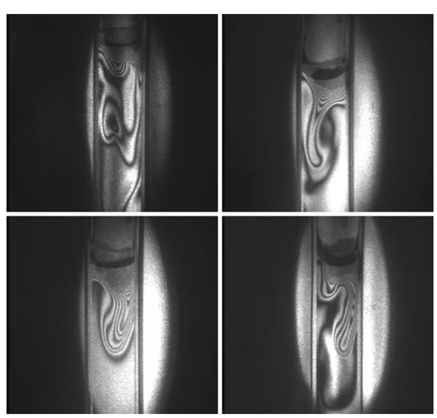

FIGURE 136.—Double exposure holograms of ice melting in water.

A miniaturized holographic system will be designed based on current optics technology. An optics breadboard table that is the same size as a Shuttle locker will be used to construct the holographic system on. Miniaturized optical components will be used to construct the system. Once a holographic system is constructed it will be tested and refined. A variety of experiments will be performed in the system to demonstrate its capabilities. Also a microgravity fluids module will be designed and developed. The system will be tested for various modes of fluids processing, such as dispersion generation, fluid delivery, and heating. The fluids module will also be added to the holographic system to help define its capabilities. The microgravity fluids module and the holographic system will be combined and tested on the KC–135.

Sponsor: Center Director’s Discretionary Fund

Biographical Sketch: William Witherow currently holds the position of AST, Basic Properties of Materials, at MSFC. He designs and fabricates optical data acquisition systems for various experiments. The areas of experiments include protein crystal growth, immiscible fluids studies, crystal growth, multicolor holography, phase-shifting interferometry, optical measurements of alloy solidification in a micro-g environment, and nonlinear optics measurements. His current work also includes image analysis, image digitization, and he also serves as the project scientist for the observable protein crystal growth facility. He holds a B.S. in engineering physics, 1977, from the University of Tennessee, Knoxville; and an M.S. in physics, 1981, from the University of Alabama in Huntsville.